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14. ABSTRACT Imaging is used in virtually every cancer patient, in many animal models of cancer, and in a large number of in vitro cancer-related experiments. Imaging research is thus fundamental to advanced cancer research. The medical physics program at the University of Chicago is recognized internationally for its research excellence and for its training of investigators at the pre-doctoral and postdoctoral level. Many of the trainees go on to careers in cancer research. We believe that exposure and immersion of undergraduate students in summer research in breast cancer imaging is expected to provide a forum for establishing a set of next-generation researchers who will pursue breast cancer research via Ph.D. or Ph.D./M.D. programs as their career. Six undergraduate students participate in research in breast cancer imaging at the University of Chicago within the laboratory and administrative structure of the well-established Graduate Programs in Medical Physics. Six summer students in the Summer 2005 quarter learned and experienced research in breast cancer imaging through didactic lectures, hands-on research, interactive research project meetings, formal research seminars, and in the writing and oral presentation of their research. All four of the mentors who participated as primary summer advisors in the grant (Giger, Halpern, Jiang, and Nishikawa) have a long history of breast cancer research and funding.

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Summer Undergraduate Research Training in Breast Cancer Imaging

INTRODUCTION

Imaging is used in virtually every cancer patient, in many animal models of cancer, and in a large number of in vitro cancer-related experiments. Imaging research is thus fundamental to advanced cancer research. The medical physics program at the University of Chicago is recognized internationally for its research excellence and for its training of investigators at the pre-doctoral and post-doctoral level. Many of the trainees go on to careers in cancer research. We believe that exposure and immersion of undergraduate students in summer research in breast cancer imaging is expected to provide a forum for establishing a set of next-generation researchers who will pursue breast cancer research via Ph.D. or Ph.D./M.D. programs as their career. Six undergraduate students participate in research in breast cancer imaging at the University of Chicago within the laboratory and administrative structure of the well-established Graduate Programs in Medical Physics. Six summer students in the Summer 2005 quarter learned and experienced research in breast cancer imaging through didactic lectures, hands-on research, interactive research project meetings, formal research seminars, and in the writing and oral presentation of their research. All four of the mentors who participated as primary summer advisors in the grant (Giger, Halpern, Jiang, and Nishikawa) have a long history of breast cancer research and funding. In addition, the summer students have attended research presentations of others in the labs (such as post-doctoral fellows, graduate students, and faculty) and each presented their research at the end of summer to researchers at the University of Chicago.

ACCOMPLISHMENTS

Six students participated in the summer undergraduate training in breast cancer imaging during the Summer of 2005. Each student was assigned to one of the four investigators on the grant (Giger, Nishikawa, Jiang, or Halpern) and performed research in their lab. In addition, the students participated in day tours to other faculty labs as well as in clinical areas such as breast MRI, diagnostic breast imaging, and CT. The students' research and accomplishments are listed below for each student.

1. Hobbs White, University of Chicago (Advisor: R. Nishikawa)

Digital breast tomosynthesis (DBT) is an emerging x-ray imaging technique that can produce a three-dimensional image of the breast. Still in the experimental stage, DBT has shown promise in being able to solve the major limitation of mammography: the superposition of tissue. Because a mammogram is a two-dimensional image of the three-dimensional breast, overlapping breast tissue can obscure cancers and the superposition of normal breast tissue can mimic cancers. The goal of the project was to measure the resolution properties of DBT as a first step to a full optimization of DBT
.
In his project, Hobbs developed resolution test tools that consisted of thin sheets of metal with straight edges. The tools needed to be thin enough to avoid artifacts, but thick enough to attenuate x rays. After designing the tool, Hobbs worked with a machinist to make the tools. He then x-rayed the tools and analyzed the resulting images to measure the resolution of a DBT system. From the edges of the test tool image, the modulation transfer function (MTF) was measured as a function of the angle of the x-ray tube. In DBT, images are made at different angles ranging from -30 to +30 degrees. Hobbs found that as the angle changed from 0 degrees that the resolution decreased.

2. Dan Gingold, University of Chicago (Advisor: Y. Jiang)

Dan Gingold was a physics major undergraduate at the University of Chicago. He joined Dr. Jiang's lab participating in research on computer-aided diagnosis. In his work, he gained knowledge in several areas of medical imaging including radiology, pathology, and computer-aided diagnosis from reading books, attending lectures, discussions with various members of the lab, and the research activity. He also learned computer programming and attained skills for accomplishing research objectives.

Dan assisted in a project for evaluating computer-aided diagnosis of breast lesion in full-field digital mammograms as malignant or benign. He helped to analyze radiology and pathology reports to identify appropriate cases for the project. He then retrieved digital images of the cases and organized the cases into an image database. He also examined radiology and pathology reports and generated a summery of some of the cases. The database is currently used in our research. Dan has since graduated from the University of Chicago and is working as a research technician in the Biological Sciences Division of the University of Chicago.

3. Brian Klein, University of Chicago (Advisor: Y. Jiang)

Brian Klein was a physics major undergraduate at the University of Chicago. He joined Dr. Jiang's lab participating in research for understanding the perception process of mammogram interpretation. He gained knowledge in observer perception experiment and receiver operating characteristic analysis for observer performance evaluation from reading journal papers, attending lectures, discussions with various members of the lab, and research activities.

Brian assisted in a project for understanding the effect of reader inattention on the reader's performance in detecting breast cancers. He researched literature and investigated whether the perception process of an experiment can be described with a mathematical model. He also participated as a reader in the observer experiment with simulated computer images and a detection task that simulates breast cancer detection in screening mammography. He also organized the experiment in which several others participated as readers. Finally, he helped summarize the results, part of which was presented at an international conference (MIPS). Brian is currently a senior and is applying for graduate school to study astrophysics.

4. Andrew Jamieson, University of Chicago (Advisor: M. Giger)

The field of computer-aided diagnosis (CAD) is rapidly growing, especially in the area of the detection and diagnosis of lesions in breast images since the earlier breast cancer is found the better the prognosis for the patient. While in Dr. Giger's lab, Andrew increased his knowledge of medical imaging through the reading of books on breast imaging, image processing, and medical physics, and through various discussions with Dr. Giger and others in the lab. He learned about scientific investigations and the corresponding need for creativity and rigor.

Andrew assisted in converting our mammographic CADx methods to a computing grid platform in order to evaluate the potential of grid computing for the training of compute-intense feature-extraction and classifier training. He validate the converted software with our prior results. Andrew is now pursuing graduate studies in medical physics with an interest in breast cancer research.

5. Nicholas P. Gruzauskas, University of Illinois at Chicago (Advisor: M. Giger)

The field of computer-aided diagnosis (CAD) is rapidly growing, especially in the area of the detection and diagnosis of lesions in breast images since the earlier breast cancer is found the better the prognosis for the patient. While in Dr. Giger's lab, Nick increased his knowledge of medical imaging through the reading of books on breast imaging, image processing, and medical physics, and through various discussions with me and others in the lab. He learned about scientific investigations and the corresponding need for creativity and rigor.

In the lab, Nick assisted in the workflow analysis of a preclinical sonographic breast CADx workstation and in the development of a web-based database manager for the multi-modality breast CADx research. The preclinical evaluation enabled Nick to observe first-hand the practice of breast cancer imaging. Due to his efforts, we are

now able to translate our computer-aided diagnosis workstation for ultrasound to the clinical breast imaging area of the Department of Radiology.

Nick will be presenting his research on the web-based CADx database manager at the 2007 SPIE meeting on Medical Imaging, which will broaden his exposure to other imaging research. Nick is now pursuing a Ph.D. in biomedical engineering with an interest in breast CADx development.

6. Phillip Smithback, University of Chicago (Advisor: H. Halpern)

EPR imaging with continuous wave acquisition continues to show improved spatial and oxygen resolution. One of the sources of this improvement is the refinement of technique. Phillip Smithback was significantly involved in a major refinement of the EPR technique during his work with us from May to September, 2005. Phillip quickly learned both the elements of the EPR experiment and the operation of the homebuilt spectroscopic imagers in the Center for EPR Imaging In Vivo Physiology. He learned empirically about Heisenberg spin exchange broadening.

In the laboratory he helped develop techniques to fabricate phantoms, models of objects to be imaged. These phantoms were fabricated with various substrate concentrations and equilibrated with different oxygen concentrations. The particular refinement to which Phillip Smithback made a major contribution was to define the confounding effect of substrate concentration on oxygen broadening of the substrate spectral lines. He participated in data acquisition and wrote analytic code to help us understand the relationship between image intensity and the substrate concentration to use the intensity measurement to correct (a small correction) the oxygen concentration images.

Phil is presently working in biophysics, using an optical tweezers to isolate single proteins to study transduction. Phil is extensively sampling the physics community to try to decide the field of choice for him.

KEY RESEARCH ACCOMPLISHMENTS

1. An ongoing summer undergraduate research program in breast cancer imaging has now been established at the University of Chicago, under the direction of M. Giger who also directs the graduate programs in medical physics.

2. The competitive program is limited to 6 undergraduate slots per summer and has successfully trained 6 students during the summer of 2005.

3. Undergraduate students are learning the rigors of research and are contributing to a level that allows for co-authorship on presentations and future papers.

4. Evidence of the influence of the program is shown through the education/career choices of the 2005 summer students with N. Gruszauskas considering MD/PhD programs in radiological imaging and BME, and A. Jamieson applying to graduate programs in medical physics.

REPORTED OUTCOMES

1. N. Gruszauskas, K. Drukker, and M. L. Giger. “An image database management system for conducting CAD research,” To be presented at SPIE Medical Imaging 2007.

CONCLUSIONS

We have established a formal summer undergraduate research program in breast cancer imaging at the University of Chicago. The students are being exposed to various laboratories and clinical areas as well as being immersed in a focused research project. They also have attended various presentations by post-doctoral fellows, graduate students, and faculty during the summer. The six summer students in the Summer 2005 quarter learned and experienced research in breast cancer imaging through didactic lectures, hands-on research, interactive research project meetings, formal research seminars, and in the writing and oral presentation of their research. All four of the mentors (Giger, Halpern, Jiang, and Nishikawa) participated as primary summer advisors in the grant.

With the start of each year, we receive multiple applications for our summer undergraduate research training program, however, now with the ending of this grant, we can only accept a few. This undergraduate summer training grant was one of the best uses of funds for educating the next generation of breast cancer researchers.